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## Chemical Properties of Chaparral Fuels Change During Preheating Before Flaming

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Two chaparral species, pointleaf manzanita (*Arctostaphylos pungens* H.B.K.) and shrub live oak (*Quercus turbinella* Greene), were analyzed for certain chemical properties known to influence flammability. Half of each sample was analyzed before heating, and the other half after heating for 5 minutes. The losses of crude fat, heat of combustion, and phosphate-phosphorus were statistically significant.

**Keywords:** *Arctostaphylos pungens*, *Quercus turbinella*, flammability.

Fuel chemistry and fuel physics have a pronounced influence on fire behavior. Lindenmuth and Davis (1973) found that the phosphate-phosphorus content of fuels affects rate of spread (ROS) appreciably. They concluded that "there is a critical threshold at 0.235 percent; with decreasing  $PO_4$  below that level ROS increases, with increased  $PO_4$  above the threshold there is no change in ROS." Crude fat (oils and waxes), water, and phosphate-phosphorus directly influence fuel flammability and total energy yield of forest fuels. Therefore, changes in these constituents during preheating before flaming may affect the flammability of fuels.

This Note reports changes, during the preheating period, in the crude fat, phosphate-phosphorus, and heat of combustion of leaves of two primary chaparral species.

### Procedure

Fully developed, live manzanita and shrub live oak leaves were collected in August (summer), October (fall), and February (winter). After the leaves were freeze-dried for 48 hours, half of each sample was set

aside as a matching control (Davis 1968). The remaining half was heated with an infrared lamp. The manzanita leaves were exposed to 428°F for 5 minutes, and the oak leaves 382°F for an equal period of time. The purpose of preheating was to simulate the effects of an approaching fire on chemical properties of the fuel before ignition. The weight loss and temperature obtained were recorded for each prepared sample. The control samples and the heated samples were then ground in a Wiley laboratory mill to pass a 40-mesh screen.

Crude fat content was measured by extracting two 1-gram subsamples with anhydrous ether for 4 hours in a Goldfish fat extraction apparatus. Samples were then oven-dried at 70°C for 24 hours, by which time a constant weight was reached.

Heat of combustion (total energy a fuel has available for release in burning) was determined in a Parr isothermal oxygen bomb calorimeter (Parr procedure).

Phosphate-phosphorus concentrations were calculated in parts per million by weight (Johnson and Ulrich 1959). Samples were treated to develop the blue phosphomolybdate color, which was then measured on a photoelectric colorimeter.

Moisture content for the above samples was determined by the Karl Fischer titration method to establish the dry-weight bases for chemical comparisons. Moisture losses due to preheating have no real meaning in this study because the leaves had been freeze dried.

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Table 1.--Effects of preheating on chemical content of chaparral fuels collected during different seasons (mean of 10 replications)

Species and season	Crude fat			Phosphate-phosphorus			Total energy			Weight loss		
	Before	After	Difference	Before	After	Difference	Before	After	Difference	Before	After	Difference
	- -	Percent	- -	p.p.m.	Percent		cal/g	Percent		- g -	Percent	
MANZANITA:												
Summer	8.0	6.6	17.5	2,549	1,711	32.9	5,122	4,763	7.0	5.27	4.69	11.0
Fall	9.6	7.7	19.8	2,538	1,217	52.0	5,264	4,815	8.5	10.04	8.90	11.3
Winter	9.3	7.7	17.2	2,316	1,666	28.1	5,377	4,731	12.0	10.11	8.82	12.7
OAK:												
Summer	2.6	2.3	11.5	3,261	2,593	20.5	4,675	4,545	2.8	5.08	4.79	5.8
Fall	4.2	4.1	2.4	3,367	1,802	46.5	4,738	4,561	3.7	5.01	4.68	6.5
Winter	5.6	4.6	17.9	2,227	2,414	8.4	4,844	4,510	6.9	10.03	9.28	7.5

## Results and Discussion

Dry chaparral leaves lost approximately 14 percent of their weight during the preheating period. The weight loss was indicated by gas vapors and smoke.

All the preheated leaves lost statistically significant amounts of water, crude fat, total energy, and phosphate-phosphorus (table 1).

Crude fat loss is also important because crude fat may contain 9,300 calories per gram, over twice the average 4,100 calories for all other fuel components combined (Crampton 1956). Davis (1968) found crude fat in manzanita to yield 9,212 calories per gram, while oak fat yielded 8,474 calories per gram. The crude fat losses did not account for the differences in total energy between the controls and the preheated samples, however.

## Conclusions and Recommendations

Chemical changes brought about by preheating reduce crude fat, moisture content, phosphate-phosphorus content, and total energy yield of chaparral fuels. The total effect of these changes would appear to increase the flammability of the fuel, in spite of the fact that some of the chemical responses appear to be offsetting. For example, preheating tends to reduce the moisture content of the fuel, thereby **increasing** flammability. However, preheating also reduces the amount of crude fat slightly, which should **reduce** flammability. Preheating reduces the amount of phosphate-phosphorus, which should result in an **increase** in flammability. However, preheating also reduces the total energy yield of the fuel,

which should make the fire **less** intense. The fact that the total of the measured losses did not account for the total weight loss caused by heating suggests that other constituents are being driven off. When these changes are based on a larger scale, such as a 20-acre fire, the effects on flammability may influence the characteristics of the fire itself.

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